

What Is Claimed Is:

1 1. A method for discovering remote nodes in an Ethernet passive
2 optical network which includes a central node and at least one remote node,
3 wherein downstream data from the central node is broadcast to the remote nodes,
4 and wherein upstream data from each remote node is transmitted to the central
5 node in a unicast manner, the method comprising:
6 receiving a solicitation message from the central node, wherein the
7 solicitation message includes a time stamp indicating the solicitation message's
8 transmission time and assigns a starting time and size for a discovery slot in which
9 the remote node is allowed to transmit a response message to the central node for
10 registration;
11 setting a local time at the remote node according to the received time
12 stamp; and
13 after a random delay from the beginning of the discovery slot,
14 transmitting the response message to the central node during the discovery slot
15 with a response transmission probability that is less than or equal to one.

1 2. The method of claim 1, further comprising setting the value of the
2 response transmission probability according to how many times the remote node
3 has failed in registering with the central node.

1 3. The method of claim 2, wherein the value of the response
2 transmission probability is $C_f^{-(j-1)}$, where
3 j is the number of previously failed registration attempts by the remote
4 node; and
5 C_f is a positive number greater than 1.

1 4. The method of claim 1, wherein the central node sets the value of
2 the response transmission probability and specifies the response transmission
3 probability within the solicitation message.

1 5. The method of claim 4, further comprising
2 setting the value of the response transmission probability according to the
3 maximum number of undiscovered remote nodes that may transmit response
4 messages for registration with the central node;
5 wherein the maximum number of undiscovered remote nodes that may
6 transmit response messages decreases as the number of discovered remote nodes
7 increases in an EPON with fixed maximum number of allowable remote nodes.

1 6. The method of claim 1, further comprising
2 setting the size of the discovery slot according to the maximum number of
3 undiscovered remote nodes that may transmit response messages for registration
4 with the central node;
5 wherein the maximum number of undiscovered remote nodes that may
6 transmit response messages decreases as the number of discovered remote nodes
7 increases in an EPON with fixed maximum number of allowable remote nodes.

1 7. The method of claim 6, wherein the size of the discovery slot is
2 proportional to the maximum number of undiscovered remote nodes that may
3 transmit response messages, and is also proportional to transmission busy time of
4 the response message.

1 8. The method of claim 7, wherein the size of the discovery slot is
2 precisely or approximately equal to $C_s \times n \times T$, where

3 C_s is a positive number;
4 n is the maximum number of undiscovered remote nodes that may transmit
5 response messages; and
6 T is the transmission busy time of the response message.

1 9. The method of claim 8, further comprising
2 storing values of the size of the discovery slot in a table based on different
3 maximum numbers of undiscovered remote nodes that may transmit response
4 messages; and
5 before sending out the solicitation message, retrieving a value of the size
6 of the discovery slot based on the current maximum number of undiscovered
7 remote nodes that may transmit response messages.

1 10. The method of claim 6, wherein size of the discovery slot is
2 approximately:

3
$$\frac{T \cdot (2n - 1) + \sqrt{T^2 \cdot (2n - 1)^2 + 8 \cdot T \cdot E \cdot (n - 1)}}{2}; \text{ where}$$

4 T is the transmission busy time of the response message;
5 n is the maximum number of undiscovered remote nodes that may transmit
6 response messages; and
7 E is the maximum round-trip propagation delay between the central node
8 and any remote node.

1 11. The method of claim 10, further comprising
2 storing values of the size of the discovery slot in a table based on different
3 maximum numbers of undiscovered remote nodes that may transmit response
4 messages; and

5 before sending out the solicitation message, retrieving value of the size of
6 the discovery slot based on the current maximum number of undiscovered remote
7 nodes that may transmit response messages.

1 12. The method of claim 6, wherein size of the discovery slot is
2 approximately:

3
$$n \cdot T + \sqrt{n^2 \cdot T^2 + 2 \cdot T \cdot E \cdot (n - 1)}; \text{ where}$$

4 T is the transmission busy time of the response message;

5 n is the maximum number of undiscovered remote nodes that may transmit
6 response messages; and

7 E is the maximum round-trip propagation delay between the central node
8 and any remote node.

1 13. The method of claim 12, further comprising
2 storing values of the size of the discovery slot in a table based on different
3 maximum numbers of undiscovered remote nodes that may transmit response
4 messages; and

5 before sending out the solicitation message, retrieving value of the size of
6 the response transmission period based on the current maximum number of
7 undiscovered remote nodes that may transmit response messages.

1 14. An apparatus for discovering remote nodes in an Ethernet passive
2 optical network, comprising:

3 a central node;

4 at least one remote node that is configured to,

5 receive a solicitation message from the central node, wherein the

6 solicitation message includes a time stamp indicating the solicitation

7 message's transmission time and assigns a starting time and size for a
8 discovery slot in which the remote node is allowed to transmit a response
9 message to the central node for registration;
10 set a local time at the remote node according to the received time
11 stamp; and
12 after a random delay from the beginning of the discovery slot,
13 transmit the response message to the central node during the discovery slot
14 with a response transmission probability that is less than or equal to one;
15 wherein downstream data from the central node is broadcast to the remote
16 nodes, and wherein upstream data from each remote node is transmitted to the
17 central node in a unicast manner.

1 15. The apparatus of claim 14, wherein the remote node is further
2 configured to set the value of the response transmission probability according to
3 how many times the remote node has failed in registering with the central node.

1 16. The apparatus of claim 15, wherein the value of the response
2 transmission probability is $C_f^{-(j-1)}$, where
3 j is the number of previously failed registration attempts by the remote
4 node; and
5 C_f is a positive number greater than 1.

1 17. The apparatus of claim 14, wherein the central node is configured
2 to set the value of the response transmission probability and specifies the
3 response transmission probability within the solicitation message.

1 18. The apparatus of claim 17, wherein the central node is further
2 configured to,
3 set the value of the response transmission probability according to the
4 maximum number of undiscovered remote nodes that may transmit response
5 messages for registration with the central node;
6 wherein the maximum number of undiscovered remote nodes that may
7 transmit response messages decreases as the number of discovered remote nodes
8 increases in an EPON with fixed maximum number of allowable remote nodes.

1 19. The apparatus of claim 14, wherein the central node is configured
2 to,
3 set the size of the discovery slot according to the maximum number of
4 undiscovered remote nodes that may transmit response messages for registration
5 with the central node;
6 wherein the maximum number of undiscovered remote nodes that may
7 transmit response messages decreases as the number of discovered remote nodes
8 increases in an EPON with fixed maximum number of allowable remote nodes.

1 20. The apparatus of claim 19, wherein the size of the discovery slot
2 is proportional to the maximum number of undiscovered remote nodes that may
3 transmit response messages, and is also proportional to transmission busy time of
4 the response message.

1 21. The apparatus of claim 20, wherein the size of the discovery slot
2 is precisely or approximately equal to $C_s \times n \times T$, where
3 C_s is a positive number;

4 n is the maximum number of undiscovered remote nodes that may transmit
5 response messages; and
6 T is the transmission busy time of the response message.

1 22. The apparatus of claim 21, wherein the central node is further
2 configured to,
3 store values of the size of the discovery slot in a table based on different
4 maximum numbers of undiscovered remote nodes that may transmit response
5 messages; and
6 before sending out the solicitation message, retrieve a value of the size of
7 the discovery slot based on the current maximum number of undiscovered remote
8 nodes that may transmit response messages.

1 23. The apparatus of claim 19, wherein size of the discovery slot is
2 approximately:

3
$$\frac{T \cdot (2n - 1) + \sqrt{T^2 \cdot (2n - 1)^2 + 8 \cdot T \cdot E \cdot (n - 1)}}{2}; \text{ where}$$

4 T is the transmission busy time of the response message;
5 n is the maximum number of undiscovered remote nodes that may transmit
6 response messages; and
7 E is the maximum round-trip propagation delay between the central node
8 and any remote node.

1 24. The apparatus of claim 23, wherein the central node is further
2 configured to,

3 store values of the size of the discovery slot in a table with regard to
4 different maximum numbers of undiscovered remote nodes that may transmit
5 response messages; and
6 before sending out the solicitation message, retrieve value of the size of
7 the discovery slot based on the current maximum number of undiscovered remote
8 nodes that may transmit response messages.

1 25. The apparatus of claim 19, wherein size of the discovery slot is
2 approximately:

3
$$n \cdot T + \sqrt{n^2 \cdot T^2 + 2 \cdot T \cdot E \cdot (n - 1)}; \text{ where}$$

4 T is the transmission busy time of the response message;

5 n is the maximum number of undiscovered remote nodes that may transmit
6 response messages; and

7 E is the maximum round-trip propagation delay between the central node
8 and any remote node.

1 26. The apparatus of claim 25, wherein the central node is further
2 configured to
3 store values of the size of the discovery slot in a table based on different
4 maximum numbers of undiscovered remote nodes that may transmit response
5 messages; and
6 before sending out the solicitation message, retrieve value of the size of
7 the response transmission period based on the current maximum number of
8 undiscovered remote nodes that may transmit response messages.

1 27. A computer-readable storage medium storing instructions that
2 when executed by a computer cause the computer to perform a method for

3 discovering remote nodes in an Ethernet passive optical network which includes
4 a central node and at least one remote node, wherein downstream data from the
5 central node is broadcast to the remote nodes, and wherein upstream data from
6 each remote node is transmitted to the central node in a unicast manner, the
7 method comprising:
8 receiving a solicitation message from the central node, wherein the
9 solicitation message includes a time stamp indicating the solicitation message's
10 transmission time and assigns a starting time and size for a discovery slot in which
11 the remote node is allowed to transmit a response message to the central node for
12 registration;
13 setting a local time at the remote node according to the received time
14 stamp; and
15 after a random delay from the beginning of the discovery slot, transmitting
16 the response message to the central node during the discovery slot with a response
17 transmission probability that is less than or equal to one.

1 28. The computer-readable storage medium of claim 27, wherein the
2 method further comprises setting the value of the response transmission
3 probability according to how many times the remote node has failed in
4 registering with the central node.

1 29. The computer-readable storage medium of claim 28, wherein the
2 value of the response transmission probability is $C_f^{-(j-1)}$, where
3 j is the number previously failed registration attempts by the remote node;
4 and
5 C_f is a positive number greater than 1.

1 30. The computer-readable storage medium of claim 27, wherein the
2 central node sets the value of the response transmission probability and specifies
3 the response transmission probability within the solicitation message.

1 31. The computer-readable storage medium of claim 30, wherein the
2 method further comprises
3 setting the value of the response transmission probability according to the
4 maximum number of undiscovered remote nodes that may transmit response
5 messages for registration with the central node;
6 wherein the maximum number of undiscovered remote nodes that may
7 transmit response messages decreases as the number of discovered remote nodes
8 increases in an EPON with fixed maximum number of allowable remote nodes.

1 32. The computer-readable storage medium of claim 27, wherein the
2 method further comprises
3 setting the size of the discovery slot according to the maximum number of
4 undiscovered remote nodes that may transmit response messages for registration
5 with the central node;
6 wherein the maximum number of undiscovered remote nodes that may
7 transmit response messages decreases as the number of discovered remote nodes
8 increases in an EPON with fixed maximum number of allowable remote nodes.

1 33. The computer-readable storage medium of claim 32, wherein the
2 size of the discovery slot is proportional to the maximum number of
3 undiscovered remote nodes that may transmit response messages, and is also
4 proportional to transmission busy time of the response message.

1 34. The computer-readable storage medium of claim 33, wherein the
2 size of the discovery slot is precisely or approximately equal to $C_s \times n \times T$, where
3 C_s is a positive number;
4 n is the maximum number of undiscovered remote nodes that may transmit
5 response messages; and
6 T is the transmission busy time of the response message.

1 35. The computer-readable storage medium of claim 34, wherein the
2 method further comprises
3 storing values of the size of the discovery slot in a table based on different
4 maximum numbers of undiscovered remote nodes that may transmit response
5 messages; and
6 before sending out the solicitation message, retrieving a value of the size
7 of the discovery slot based on the current maximum number of undiscovered
8 remote nodes that may transmit response messages.

1 36. The computer-readable storage medium of claim 32, wherein size
2 of the discovery slot is approximately:

$$3 \quad \frac{T \cdot (2n - 1) + \sqrt{T^2 \cdot (2n - 1)^2 + 8 \cdot T \cdot E \cdot (n - 1)}}{2}; \text{ where}$$

4 T is the transmission busy time of the response message;
5 n is the maximum number of undiscovered remote nodes that may transmit
6 response messages; and
7 E is the maximum round-trip propagation delay between the central node
8 and any remote node.

1 37. The computer-readable storage medium of claim 36, wherein the
2 method further comprises
3 storing values of the size of the discovery slot in a table based on different
4 maximum numbers of undiscovered remote nodes that may transmit response
5 messages; and
6 before sending out the solicitation message, retrieving value of the size of
7 the discovery slot based on the current maximum number of undiscovered remote
8 nodes that may transmit response messages.

1 38. The computer-readable storage medium of claim 32, wherein size
2 of the discovery slot is approximately:
3 $n \cdot T + \sqrt{n^2 \cdot T^2 + 2 \cdot T \cdot E \cdot (n - 1)}$; where
4 T is the transmission busy time of the response message;
5 n is the maximum number of undiscovered remote nodes that may transmit
6 response messages; and
7 E is the maximum round-trip propagation delay between the central node
8 and any remote node.

1 39. The computer-readable storage medium of claim 38, wherein the
2 method further comprises
3 storing values of the size of the discovery slot in a table based on different
4 maximum numbers of undiscovered remote nodes that may transmit response
5 messages; and
6 before sending out the solicitation message, retrieving value of the size of
7 the response transmission period based on the current maximum number of
8 undiscovered remote nodes that may transmit response messages.